THE INSTITUTE OF PAPER CHEMISTRY

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EFFECT OF DIAPHRAGM LUBRICATION ON DIAPHRAGM PRESSURE AND BURSTING STRENGTH

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EFFECT OF DIAPHRAGM LUBRICATION ON DIAPHRAGM PRESSURE AND BURSTING STRENGTH

SUMMARY

When bursting strength diaphragms are purchased, above specification (in terms of diaphragm pressure) diaphragms are frequently encountered. As a result large expenditures of time may be required in searching through the lot for acceptable diaphragms. In the extreme case, no acceptable diaphragms may be found.

For "emergency" use in the latter case, two means of reducing diaphragm pressure were investigated. They were

a. a stress-relaxation technique

b. lubrication of diaphragm surface.

The stress-relaxation technique consisted of holding the diaphragm at 1.8-cm. distention for various periods of time. In the second technique, graphite or silicone lubricants were applied to the top surface of the diaphragm.

The following results were found:

1. While the stress-relaxation technique reduced diaphragm pressure, short recovery periods were sufficient to restore the diaphragm pressure to about its initial level. Therefore, the technique was judged to be unsatisfactory.

2. Application of the lubricants reduced diaphragm pressure by from 8 to 12 p.s.i. g. For example, graphite lubricant dropped diaphragm pressures from about 35 to 27 p.s.i. g. for a number of current commercial diaphragms.

3. In general, lubrication decreased bursting strength slightly. This is in the desired direction as the untreated diaphragm would produce slightly higher than normal bursting strength results because their diaphragm pressures were all above 30 p.s.i. g.

Therefore it was concluded that the lubrication technique might be employed as an emergency measure when all available diaphragms give above specification diaphragm pressures.

INTRODUCTION

In attempting to comply with present diaphragm specifications of 23 to 30 p.s.i. g. at 3/8-inch distentions, a situation may arise where all or a large part of a given lot of purchased diaphragms fail to meet specifications. Large expenditures of time may then be required in searching through the lot for acceptable diaphragms.

Above-specifciation diaphragms are common. Therefore, it was thought desirable to undertake a limited study of means of reducing the diaphragm pressure of a given diaphragm to bring it within specifications. Two avenues of approach were investigated as follows:

1. After installation and determination of initial diaphragm pressure, the diaphragm was distended to 1.8 cm. and allowed to remain in the distended position for various periods of time. Any stress relaxation occurring during the period of distention would have the effect of lowering the diaphragm pressure.

2. The effect of lubricants applied to the diaphragm on both diaphragm pressure and bursting strength was also investigated.

The latter approach is not new. For example, in Reference (1) it was demonstrated that lubrication of the Cady diaphragm measureably affected bursting strength results. Unpublished work in this laboratory some years ago studied the effect of lubricated Mullen-type diaphragms on bursting strength with somewhat inconclusive results. An exhaustive literature survey was not deemed necessary for the purposes of this study and other references in the literature may exist.

While the lubricated diaphragm technique may be effective in reducing the diaphragm pressure and bursting strength results obtained with ostensibly above-specification diaphragms (as developed in later pages), the technique can only be recommended as a possible "emergency" measure. Thus these limited data are not sufficient to indicate that equivalent bursting strength results would be obtained from normal and lubricated diaphragms having the same diaphragm pressure.

PROCEDURES

I. Stress-Relaxation Technique

A. Materials

1. Three current commercial diaphragms--Sirvene No. 3356
2. Three Sirvene 409241 diaphragms

B. Tester: Model A tester with 60-lb. gage.

C. Procedure: For each diaphragm

1. Adjust the diaphragm height in its retracted position so that its upper surface is flush with the upper plate.
2. Distend the diaphragm to approximately 1.8 cm. ten times.
3. Check to determine if the upper surface of the diaphragm in its retracted position is still flush with the lower plate and adjust if necessary.
4. Determine the pressure required to distend the diaphragm to 3/8 inch. Make four repeat determinations and average the results.
5. Distend the diaphragm to approximately 1.8 cm. for time periods of 5, 15, 60, and 120 minutes. After each time period, measure the diaphragm pressure at 3/8 inch as in parts 3 and 4 above.
6. Allow a recovery period of 15 minutes after the 120-minute period and recheck diaphragm pressure.

II. Lubrication Technique

A. Materials

1. Diaphragm types

a. Current commercial--Sirvene 3356

b. Sirvene 409241.

2. 42-lb. kraft liner--conditioned and randomized at 50 ± 2% R. H. and 73°F.

B. Lubricants

1. Graphite
2. Silicone grease (Dow Corning stopcock grease).

C. Lubrication conditions

1. Restricted to "thin" portion of diaphragm
2. Over entire top surface of diaphragm except rim area--i.e., center and "thin" area.

Note: Trials with the Sirvene 409241 diaphragms were restricted to Condition 1 because only a few diaphragms of this type remained in stock. For the same reason, the number of diaphragms evaluated for each condition were also reduced.

D. Number of diaphragms evaluated:

1. Current commercial diaphragms: Three diaphragms for each for each condition.
2. Sirvene 409241 diaphragms. Two diaphragms at each condition.

E. Procedure:

1. Install each diaphragm and determine diaphragm pressure as defined in I-C
2. Perform 50 tests on linerboard (wire side down)
3. Measure diaphragm pressure as in I-C, parts 3 and 4.

DISCUSSION OF RESULTS

The stress relaxation results are summarized in Table I. Referring to the table it may be noted the diaphragm pressure at 3/8-inch decreased as a function of the duration of time the diaphragm was held at 1.8-cm. distention. However, relatively short periods of recovery in the retracted position were sufficient to restore the diaphragm pressure to near its original level. Therefore, it is felt that this technique would not be of assistance in using above-specification diaphragms.

The effect of applying a lubricant to the diaphragm surface on diaphragm pressure and bursting strength may be seen in Tables II and III. In the tables it may be noted that

1. The lubricants reduced the diaphragm pressure of the current commerical diaphragms (Sirvene No. 3356) at 3/8-inch by from about 8 to 12 p.s.i. While all three untreated current commercial diaphragms exhibited above-specification diaphragm pressures, the graphite lubricated diaphragms were well within specifications and the silicone treated diaphragms were just outside the lower limit of 23 p.s.i.

2. Similar reductions in diaphragms occurred for the experimental Sirvene 409241 diaphragms, however, even after lubrication these diaphragms gave above-specification diaphragm pressures.

3. In general, lubrication decreased the bursting strength slightly as would be expected from the decrease in diaphragm pressure. This is in the desired direction as the untreated diaphragms would produce slightly higher bursting strength results than normal due to their high diaphragm pressure.

TABLE I

EFFECT OF VARYING PERIODS OF STRESS RELAXATION ON DIAPHRAGM PRESSURE

Time	Diaphragm Pressure at 3/8-inch Distention, p.s.i. g.[b] Current Commercial Diaphragms Diaphragm No. 1	2	3	Av.	Experimental Sirvene 409241 Diaphragms Diaphragm No. 1	2	3	Av.
at 1.8-cm. Distention, min.[c]								
0[a]	34.2	35.0	35.1	34.8	48.9	48.4	48.6	48.6
5	33.2	33.9	34.9	34.0	45.5	47.2	46.4	46.4
15	31.6	32.5	33.5	32.5	42.1	45.5	46.0	44.5
60	31.4	31.6	33.6	32.2	38.9	46.4	43.8	43.0
120	--	31.6	33.2	32.4	37.5	44.9	43.4	41.9
after 15-minute recovery[d]	31.9	35.5	35.4	34.3	43.4	49.8	45.1	46.1
after 45-minute recovery[d]	--	--	36.1		--	--	49.1	

[a] Diaphragm extended to 1.8 cm. 10 times before taking measurements at 3/8-inch distention.
[b] Each value in the table is the average of 4 measurements.
[c] Diaphragm held at 1.8 cm. for the indicated periods of time.
[d] Diaphragm allowed to recover in retracted position for indicated time period.

TABLE II

EFFECT OF LUBRICANT ON DIAPHRAGM PRESSURE AND BURSTING STRENGTH

Condition	Diaphragm Pressure at 3/8-inch Distention, p.s.i. g. Before Testing[a] Diaphragm No. 1	2	3	Av.	After Testing Diaphragm No. 1	2	3	Av.	Bursting Strength, p.s.i. g. Diaphragm No. 1	2	3	Av.
Current Commercial Diaphragms												
Untreated	35.2	34.2	34.8	34.7	35.0	34.4	35.4	34.9	125.6	125.6	126.2	125.8
Graphite on thin and center area	26.9	25.9	27.1	26.6	27.0	26.4	27.9	27.1	122.1	124.0	124.4	123.5
Graphite on thin area	26.4	25.9	26.6	26.3	26.4	26.4	27.2	26.7	126.9	124.7	125.4	125.7
Silicone on thin area	22.4	22.8	22.6	22.6	23.1	23.2	22.9	23.1	122.1	122.1	123.7	122.6
Experimental Sirvene 409241 Diaphragms												
Untreated	49.4	49.5	--	49.4	51.2	51.8	--	51.5	131.1	130.7	--	130.9
Graphite on thin area	37.6	38.6	--	38.1	40.1	40.5	--	40.3	126.5	125.4	--	126.0
Silicone on thin area	39.1	--	--	--	40.5	--	--	--	127.3	--	--	--

[a] Measurements at 3/8-inch taken after preworking the diaphragms 10 times to 1.8-cm. distention.

TABLE III

SUMMARY OF LUBRICATED DIAPHRAGM RESULTS

Condition	Diaphragm Pressure, p.s.i. g.	Difference, p.s.i. g.	Bursting Strength, p.s.i. g.	Difference, p.s.i. g.
	Current Commercial Diaphragms			
Untreated	34.8	--	125.8	--
Graphite on thin and center area	26.8	-8.0	123.5	-2.3
Graphite on thin area	26.5	-8.3	125.7	-0.1
Silicone on thin area	22.8	-12.0	122.6	-3.2
	Sirvene 409241 Diaphragms			
Untreated	50.4	--	130.9	--
Graphite on thin area	39.2	11.2	126.0	-4.9

When the effect of diaphragm pressure on bursting strength was studied, it was estimated that the present tolerance of 23 to 30 p.s.i. (7 p.s.i. g. change) may permit about 2 p.s.i. g. differences in bursting strength of kraft liner (2). The changes in bursting strength of 0.1 to 3.2 p.s.i. g. for the current commercial diaphragms for 8 to 12 p.s.i. g. decreases in diaphragm pressure appear to be of the correct order of magnitude. Similarly the change in bursting strength of about 5 p.s.i. g. for the Sirvene 409241 diaphragms appears reasonable although some extrapolation of the previous results is required because of the high diaphragm pressures encountered with these diaphragms.

It is reasoned, therefore, that this technique might be employed as an "emergency" measure to permit continued testing when all available diaphragms give above-specification diaphragm pressures. The above results, however, are not entirely consistent nor do they prove that lubricated and unlubricated diaphragms having equal diaphragm pressures necessarily give equal bursting strength results. For these reasons, use of the technique can only be considered an expedient at this time.

It may be remarked that hand stretching of diaphragms prior to their insertion in the tester is sometimes employed in an effort to obtain satisfactory diaphragm pressures. While effective, it is quite possible that oil from the fingers serves as a lubricant and, at least temporarily, reduces the diaphragm pressure.

LITERATURE CITED

1. Investigation of variables affecting bursting strength results obtained with the Cady tester. Bursting strength report 13, April 15, 1950.

2. Effect of diaphragm pressure on bursting strength. Preliminary Report Three to the FKBI, Project 1108-26. June 6, 1961.